MICROSTRUCTURAL INVESTIGATION OF A WARK-LOVERING RIM ON A VIGARANO CAI.

J. Han[1,2], L. P. Keller[2], A. W. Needham[2,3], S. Messenger[2], and J. I. Simon[2]. [1]USRA-LPI, Houston, TX 77058, USA (jangmi.han@nasa.gov). [2]NASA-JSC, Houston, TX 77058, USA. [3]Oak Ridge Associated Universities, Oak Ridge, TN 37831, USA.

Introduction: Wark-Lovering (WL) rims are thin multi-layered mineral sequences that surround many CAIs [1]. These rim layers consist of the primary minerals found in the CAI interiors, but vary in their mineralogy [1]. Several models for their origin have been proposed including condensation [2], reaction with a nebular gas [3], evaporation [4], or combinations of these [5,6]. However, there still is little consensus on how and when the rims formed. Here, we describe the microstructure and mineralogy of a WL rim on a type B CAI from the Vigarano CV_{red} chondrite using FIB/TEM to better understand the astrophysical significance of WL rim formation.

Sample and Methods: The CAI, "Big Guy", consists of a core of grossmanite and a thick mantle of reversely zoned melilite surrounded by a WL rim and an accretionary rim. Euhedral spinel grains occur throughout the core and mantle. The WL rim includes the following sequence: (1) an innermost layer of hibonite, (2) a spinel layer with minor hibonite and perovskite inclusions, (3) a gehlenite layer, (4) an anorthite layer, and (5) a layer of zoned diopside outward from Al-rich to Al-poor. The accretionary rim is dominated by forsterite with metal and micro-CAIs.

We prepared FIB sections from the edge of the melilite mantle and the WL rim using a FEI Quanta 600 3D dual beam FIB-SEM at JSC. The FIB sections were characterized in detail using a JEOL 2500SE field-emission scanning TEM and a Thermo-Noran thin-window energy dispersive x-ray spectrometer at JSC.

Results and Discussion: The edge of the melilite mantle consists of a 10-20 µm thick zone of µm-sized, nearly pure gehlenite grains with sub-µm-sized inclusions of hibonite, spinel, perovskite, and rare grossite. These observations suggest that the margin of the CAI was recrystallized at the initial stage of WL formation, possibly as a melt layer. Individual rim layers from hibonite to diopside consist of polycrystalline, µm-to-nm-sized grains with random orientations. Hibonite is typically lath shaped, but other minerals have highly irregular grain shapes. It is therefore likely that the observed mineral sequence in the WL rim formed by condensation at increase partial pressures of Si and Mg [5,6]. The anorthite layer is discontinuous and intergrown with the gehlenite layer. Al-Mg isotopic data of the WL rim indicate that anorthite formed later than gehlenite [7], as a late-stage nebular alteration product of the gehlenite layer. The diopside layer shows increasing grain size outward, probably due to a later nebular metasomatism from the outside.

Collectively, these observations suggest that the WL rim formed by multi-stage high-temperature processes under disequilibrium conditions.

References: [1] MacPherson G. J. 2014. Treatise on Geochemistry II pp.139-179. [2] Wark D. A. and Lovering J. F. 1977. LPS 8:95-112. [3] Ruzicka A. 1997. JGR 102:13387-13402. [4] Wark D. and Boyton W. V. 2001. MAPS 36:1135-1166. [5] Simon J. I. et al. 2005. EPSL 238:272-283. [6] Keller L. P. et al. 2013. MAPS 48:A166. [7] Needham A. W. et al. 2015. this volume.